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Archaeoastronomy and Conflict: On the Orientation of Prehistoric Funerary Monuments in Western Sahara

Andrea Rodríguez-Antón [1,*], Maitane Urrutia-Aparicio [2] and María Antonia Perera Betancor [3]

[1] Instituto de Ciencias del Patrimonio, Consejo Superior de Investigaciones Científicas (INCIPIT-CSIC), 15707 Santiago de Compostela, Spain
[2] Instituto de Astrofísica de Canarias (IAC), Universidad de La Laguna, Calle Vía Láctea s/n, 38200 La Laguna, Spain
[3] Cultural Heritage of Canarias, Gobierno de Canarias, 38270 San Cristóbal de La Laguna, Spain
* Correspondence: andrea.rodriguez-anton@incipit.csic.es

Abstract: A variety of Prehistoric dry-stone monuments are ubiquitous in Western Sahara, a region delimited by the boundaries of the former Spanish colony. With either burial or ritual functions, these monuments are spread throughout the Sahara Desert creating sacred landscapes and housing the memory of millennia of occupation. Previous research has explored the role of the sky in various aspects of the life of early inhabitants, such as their religious beliefs or funerary practices. These have been identified by the patterns of location and orientation of these constructions and their relation to particular astronomical events. This work presents a statistical analysis of the orientation of more than 200 prehistoric dry-stone monuments in Western Sahara occupied by Morocco, currently the biggest sample ever studied in this area and the first unique sample obtained in situ. The results show that the orientations follow similar trends observed in other areas of North Africa and the Mediterranean and that they fit with the visibility of particular celestial objects. This provides new insights into the ideas about space, time, and death and the cultural changes and mobility of those peoples and contributes to the preservation of a highly threatened heritage that is immersed in a vast land currently under dispute.

Keywords: archaeoastronomy; cultural astronomy; archaeology of Western Sahara; threatened heritage; North Africa prehistory; funerary archaeology; archaeology of North Africa; dry-stone monuments; sacred landscapes

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1. Introduction

This paper presents an approach to the cosmovisions of Prehistoric Saharan communities, framed within the perspective of Cultural Astronomy, in particular, Archaeoastronomy [1]. To achieve our goal, we studied the orientations of more than 200 dry-stone funerary and ritual monuments of different types, distributed through a wide area of Moroccan-controlled Western Sahara. Observing the orientation patterns, together with other features such as the spatial distribution of the monuments, our aim was to explore whether there existed some connection between the construction of these monuments and particular elements of the surrounding landscape or specific celestial bodies or phenomena. In addition, if this was indeed the case, we wanted to explore what was observed, when, and why. Specifically, we were interested in whether any of the observed patterns responded to particular beliefs, practices, notions of time and space of the earlier inhabitants, and, in general, their ideas about the territory and the world.

Present-day Western Sahara—defined by the borders of the previous Spanish colony, commonly known as Spanish Sahara—is located in the westernmost extremity of the Sahara Desert and limited by Morocco to the north, Algeria to the east, Mauritania to the south, and approximately 1200 km of Atlantic coast to the west. This region has been inhabited for millennia, as well as being the stage for different and changing cultural expressions, which necessarily adapted to several environmental transformations that took place in what is now the third-largest desert in the world.

Part of the legacy of these human processes is found in the abundant and varied archaeological records spread across the territory, such as paintings, engravings, inscriptions, and stone constructions associated with Prehistoric human occupations. A considerable number of these remains are dry-stone monuments of various typologies, generally related to funerary and ritual purposes, which are present in many Saharan regions—with more or less similarities—and are ubiquitous in Western Sahara.

Unfortunately, this region has been in conflict with Morocco since the Spanish withdrawal in 1975. This event has resulted in a long-standing war with Morocco, which was reactivated in 2020. This has led to the displacement of thousands of Sahrawis to refugee camps near the Algerian city of Tindouf (where they still live) and the division of the colonial territory by the 3000 km-long Moroccan wall into one part controlled by Morocco to the west (Occupied Territories, 80% of the former region) and the other part by the auto-proclaimed Sahrawi Arab Democratic Republic (SADR or the Free Zone), governed by the Sahrawi independence movement "Frente Polisario", to the east (Figure 1).

Figure 1. United Nations map of Western Sahara showing the division of the land by the Moroccan wall or 'berm'. The fieldwork discussed in the text was carried out on the western side of the berm.

Both the colonial and the present political context, together with environmental constraints, have limited in-depth study of the Pre and Proto-historic burials and sacred constructions, as well as of the related materials beneath. However, in recent decades, various international research groups have undertaken notable archaeological work in the area, mostly in the Free Zone [2,3]. This has provided a relevant amount of information about the societies that inhabited what is now Western Sahara and its neighboring territories. Several of these studies focused on the patterns of location of the different funerary monuments and their possible relation to the surrounding landscape; they also considered their relation to the skyscape, understood as the ways people connect the sky with conceptions of their daily life such as time, space, or religion.

One of the first archaeoastronomical studies of these types of structures took place in central and south Morocco, in the necropolises of Foum al Rajm and Tauz al Qadim, which date from the 1st millennium BCE [4,5]. Tombs at these sites presented predominant orientation patterns towards the south-east sector of the solar rising range, and many of them coincide with positions of the rising sun at the equinoxes and the moon at its southernmost rising position. Similar results toward the south-east lunisolar range were obtained a few years later for different types of dry-stone constructions in various regions of the Sahara, from Fezzan (Libya) to Teneré (Niger) and Mauritania [6]; the same patterns for this type of structure were also found in various areas of central and Western Sahara [7,8] (p. 199).

In all these works, authors suggest that astronomical alignments may have been combined, on some occasions, with positioning above, or with respect to, particular topographic features; however, this would occur only locally for particular types of monuments and any element of the landscape could explain the generally shared pattern of orientation that arises in the above-mentioned regions towards the eastern horizon.

In this work, we analyze this first and unique sample of orientations of these types of structures in this area obtained in situ. Our results could add relevant information to that extracted from other archaeoastronomical works and archaeological records about the relationship between space, notions of time, mobility, and cultural changes of the Saharan Pre and Proto-history inhabitants.

While these outcomes favor the consideration of the Sahrawi monuments within a wider framework of Prehistoric funerary practices and beliefs, more importantly, this research contributes to the documentation and preservation of such a threatened heritage, widely dispersed across miles of desert currently under dispute (Figure 2). Even though the relative isolation of these constructions means they remain relatively undisturbed, this abandonment and the lack of preservation policies entail various threats; this is because several archaeological artifacts and structures have been endangered, stolen, or moved illegally to particular collections. Furthermore, a break in the ceasefire between Morocco and the Polisario Front in 2020 and the consequent recent return to armed conflict pose additional direct threats to these and further archaeological remains.

Figure 2. Prehistoric standing-stone alignment with blue painted markings, apparently made during the organization of the Dakar Rally.

2. Materials and Methods

2.1. Data Sample

This study includes the archaeoastronomical data from 217 Prehistoric dry-stone monuments in Western Sahara occupied by Morocco. The data were obtained by the authors during two fieldwork campaigns in 2018 and 2019 and constitute the largest sample of this kind ever studied in this region (see Appendix A). During the expeditions, a multidisciplinary team of researchers had the opportunity to record the location and characteristics of hundreds of dry-stone constructions of different typologies and measure the orientations of more than 200 of them. Unfortunately, some of the constructions had deteriorated and no privileged direction could be determined.

The campaigns were undertaken in the southern part of Western Sahara under Moroccan control, mostly between Dakhla and Ausserd (Figure 3), a territory that hosts a variety of desert landscapes in which mountains co-exist with lowlands.

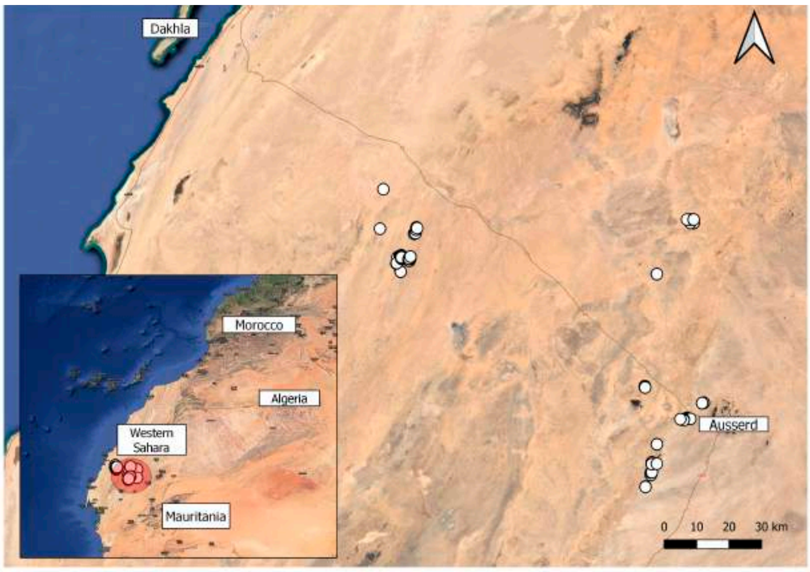

Figure 3. Map with the location of the monuments in the sample. Note that the circles indicate nearby groups, and not individual structures, due to their high number.

The present dataset includes various morphological groups of dry-stone structures, generally attributed to funerary uses and markers of sacred places [9]. According to some authors [10] (p. 23), [11] (pp. 2–4), these structures likely emerged in the context of climate desertification in the Sahara around the 7th millennium BCE; this may have led to a change from a subsistence lifestyle to the adoption of pastoral and semi-pastoral lifestyles.

We have divided this sample into groups according to classifications made in previous works in other areas of the Sahara where monuments present architectural and structural similarities [12]. We have, however, adapted previous classifications to the particularities of our data so that we differentiate four main types (Figure 4):

- Circular tumuli, generally accompanied by a reference stone or a smaller companion tumulus.
- Monuments with annexed structures such as chapels, false entrances, antennae, and any other kind of reference features associated with the main tumulus. Non-circular tumuli with annexed structures are included in this group.
- V-shaped structures, primarily crescents [9] (p. 352), also classified within 'falcates' [12] (p. 42, Figure 3.2)
- Standing stone alignments or lines of orthostats, some of them decorated, that could also follow a curved line and are included in the cairns group by Nick Brooks et al. [12] (p. 43, Figure 3.3)

Figure 4. Different types of monuments included in the sample: Circular tumulus (**a**), an example of tomb with structure (**b**), two crescents (**c**), and a standing stone structure (**d**).

In our sample, almost half of the monuments are tumuli with some structure, e.g., antennae or false entrances, among others, 25% are circular tumuli, 8% are crescent-shaped monuments, and 20% are standing stone alignments.

In addition to structural diversity, the different kinds of constructions here cover a wide chronology across different areas. Unfortunately, in most cases, we can merely speculate on the construction period. The main reason for this is that only a few have been excavated in the region (none of them from this sample) and due to the lack of material remains in many instances, even fewer could be dated accurately enough. However, the earliest monuments are considered to be from approximately 3500 BCE (generally the circular tumuli) and the latest from the first centuries of CE. In this last group, the largest and most elaborate structures are included, some of which even date from the 3rd to the 7th centuries CE [12], [13] (p. 7), [14]. These time ranges are partially manifested by the constructive and material record similarities of the monuments from Western Sahara to others from diverse areas of the Sahara that could be dated more accurately, such as Algeria, Niger, southwest Libya, and even Ethiopia [15]. Undoubtedly, such a wide timespan suggests the continued occupation of this region for a considerable period of time.

2.2. Methodology

As mentioned above, all the data were obtained in situ and the magnitudes measured are the azimuth (A, defined as the angle from geographic north clockwise) of the selected structure and the altitude of the horizon (h) for each azimuth. This is in order to consider the surrounding landscape and how the topography affects the visibility of the celestial bodies. These magnitudes were measured with a Silva tandem including a clinometer for the acquisition of the altitudes of the horizon and a precision compass for the azimuths, which allow accuracies of $\pm 0.5°$ and $\pm 0.25°$, respectively. Since north given by the compass does not coincide with the geographic north, all azimuth values were corrected of magnetic declination, using the most recent World Magnetic Model (WMM) provided by the National Oceanic and Atmospheric Administration (NOAA) [16].

Due to the morphological diversity of the monuments, the methodologies applied to determine the privileged direction and to measure the orientations differ from one type to another. Even though, in most cases, the simple circular tumuli have circular symmetry (sometimes it was not exactly circular but rather ellipsoidal), the orientation of the line between the tumulus and a reference stone or other companion structure (if any) was recorded. In addition, we measured the line connecting two tumuli (from the biggest to the smallest one), and a number of them had a rectangular cist at the top so we considered the long axis of these structures. Even though many more tumuli were recorded, their orientation could not always be determined due to the absence of annexed or companion structures that served as references. However, in these cases, other features such as the use of contrasting materials, or the place in which they were located in relation to the surrounding territory, could offer additional and valuable information.

For the monuments with some structure, the latter were the elements that determined the orientations; for example, corridors, 'false entrances', or chapels. For the crescents and tumuli with antennae, the chosen direction was that towards which they 'opened' to taking the bisector angle (Figure 5), following the same method of previous authors [6] (Figure 2), [12] (pp. 42–47). This procedure was also applied to the lines of orthostats when they followed a lunar-shaped line or had antennae.

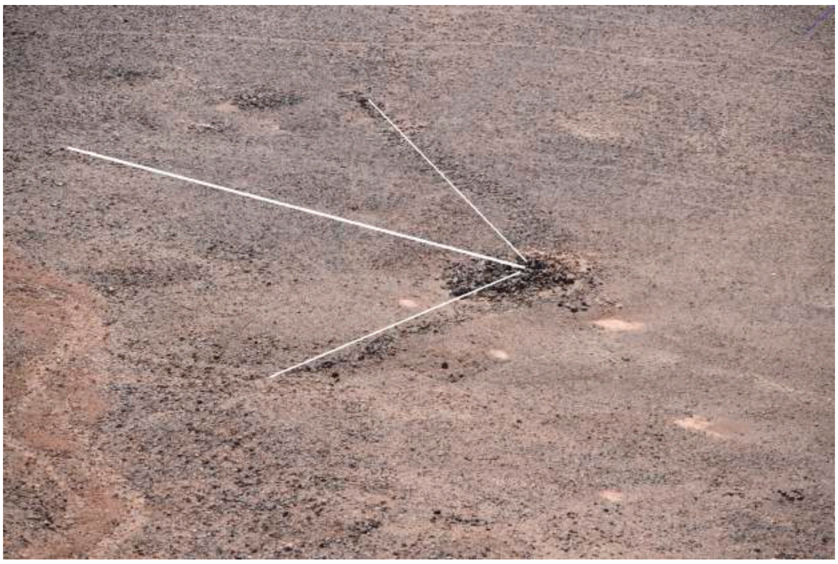

Figure 5. Measurement procedure for the orientation of crescents and v-shaped monuments. The middle line indicates the bisector line, which is the direction considered.

For the straight lines of standing stones with decorations on one of the sides of the orthostats, we considered the perpendicular direction to the line of stones facing from the side on which the orthostats were decorated. Various monuments of this type had considerably deteriorated, so only those better preserved were measured to minimize the uncertainty in the results. In addition, further targets such as the position of the structures in reference to the surrounding landscape and the possible visibility of astronomical phenomena above conspicuous elements of the horizon were explored in areas with topographical particularities; this will be discussed later.

2.3. Data Analysis

To take into account how both the local topography and the geographical location affect the visibility of celestial objects, another astronomical magnitude, declination (δ), was obtained. This allows a direct comparison between its value and the visibility of a specific celestial object above the horizon, independently of the location of the observer on the Earth, as shown in Equation (1). It depends on the azimuth (A), the altitude over the horizon (h), and the latitude (φ). For the calculation of the declination, the effects of the atmospheric refraction [17] and the changes in the obliquity of the ecliptic were considered [18] (pp. 3–5). The instrumental errors introduced by both the compass and the clinometer are $\pm 0.25°$ and $\pm 0.5°$, respectively, which translates to an error of $\pm 0.75°$ in declination. In every case, various measurements were performed on the same element in order to reduce the errors, but the predominant damaged state of preservation forced us to consider a more conservative value of $\pm 3°$ for the circular tumuli and $\pm 1.5°$ for the other types.

$$\sin \delta = \sin h \sin \varphi + \mathrm{con}\, h \cos \varphi \cos A \tag{1}$$

Both the azimuth and the declination data are represented by curvigrams, where data are normalized by the relative frequency of the mean. Curvigrams present a smoothness of the usual histograms by a function called kernel to produce the azimuth and declination probability density functions. This is calculated by multiplying each value by the kernel function, which in this case is an Epanechnikov kernel with a determined bandwidth, which is generally twice the error estimated added together. However, other values can be carefully selected considering the size of the sample to avoid oversmoothed or too-sharp distributions [19].

3. Results

3.1. The Role of the Topography

Previous studies in Western Sahara and nearby areas propose the existence of patterns in the type of terrain chosen for the development of funerary and ritual architecture, as identified in pre-Islamic necropolises in South Morocco [4–6] and Western Sahara [7]. In these areas, locations such as ridges or drainage systems seem to have been preferred, possibly in order to gain visibility from greater distances and even to mark Trans-Saharan connective routes [8] (p. 199), [9] (pp. 341–344), [20].

For this reason, in addition to the orientation patterns, the existence of topographical motivations underlying the location and the orientation of the structures was explored. Specifically, we examined whether any patterns exist in the distribution and the election of particular natural spaces—such as locations on water basins, plains, or ridges—as well as the visibility of special topographic features in the vicinity.

In the full sample, different types of monuments sometimes share the same spaces, and no unique or clear geographic pattern was identified (Figure 6). However, in some instances, particular groups stand effectively above mountainous ridges or near water basins, others are on plains with excellent visibility of the surrounding territory, and a number of small groups were in *oueds* (dry river basins) or *hamadas* (drier flat lands).

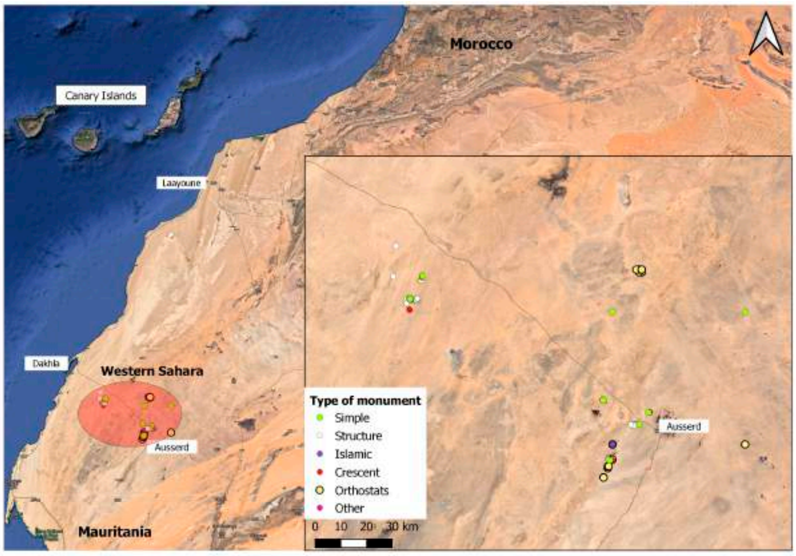

Figure 6. Map of distribution of the different types of structures in the sample. Note that bigger concentrations of the same type of monuments indicate nearby, and not individual structures, due to their great number.

One of the groups of monuments studied independently is in the area around the *Awsili Ngjir* and *Gub Garaya* mountains (Figure 7), the local name for a number of outstanding mountains.

Figure 7. View of the *Gub Garaya* mountain behind an obelisk decorated with Libyco-Berber inscriptions.

Not all the tombs in these areas present the same typology. Around *Gub Garaya*, for example, tombs with diverse structures—such as antennae, entrances or 'false entrances', and reference stones—could be found. They also do not display a clear pattern of orientation since, in some cases, the selected direction seems topographical, particularly towards the surrounding high mountains. In other cases, however, they follow the general trend of facing east, as will be discussed later. Occasionally, and regardless of the typology, a number of monuments appear to face or are adapted to the slope of a mountain, as occurs for a group that presents orientations towards the west and for a few tombs on Mount *Awsili Ngjir*. This place was likely a sacred spot in the past, as inferred by the presence of several cupules and ceramics at the base and the top, where there are great views of the surrounding territory (Figure 8).

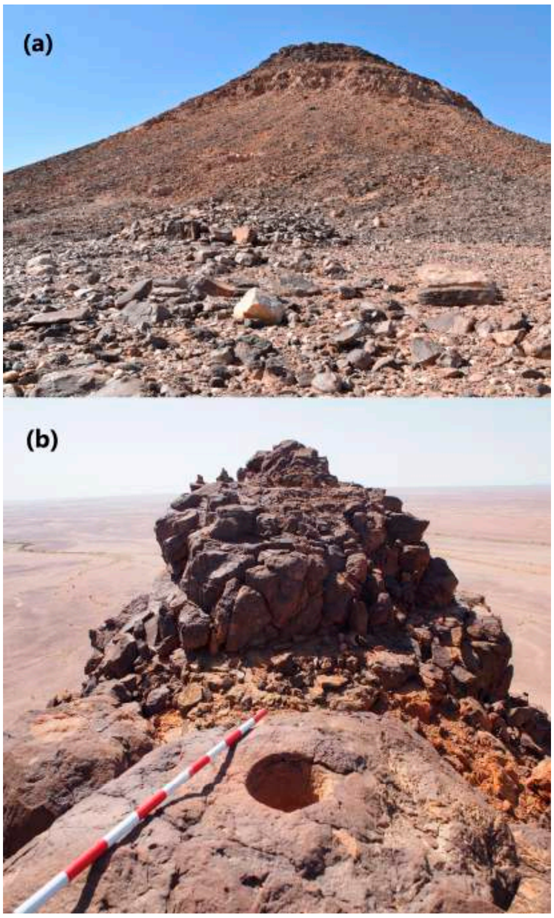

Figure 8. *Awsili Ngjir* mountain from the basement (**a**) and cupules and views from the top (**b**).

A minor group of monuments was built on the eastern slope of this mountain, resulting in a general local pattern of orientations towards the south-east, in particular within an azimuth range from 120° to 160°. The structures found here were tumuli with a 'false entrance' and one with antennae that incorporated contrasting materials, particularly quartz.

A number of monuments near Ausserd in a place called *Boularyah*, which means "father of the wind" according to the local people, constitute another group possibly affected by environmental conditions. These structures are close to an *oued* that, as mentioned above, is an Arabic term for a valley or dry river basin where water flows seasonally or when heavy rains occur (Figure 9). Here, several inscriptions with representations of animals and spirals can be identified, as well as circular tumuli, tombs with antennae, and some Islamic burials, conceivably resulting from the relevance and continuous use of this space for ritual and funerary purposes. The monuments in this area are oriented predominantly towards the south-east within the lunisolar rising arc, and the three with antenna open towards an azimuth range from 120° to 130°. The majority of these structures were circular tumuli and, unfortunately, highly deteriorated, so the orientations are very inaccurate and many of them could not be included in the sample.

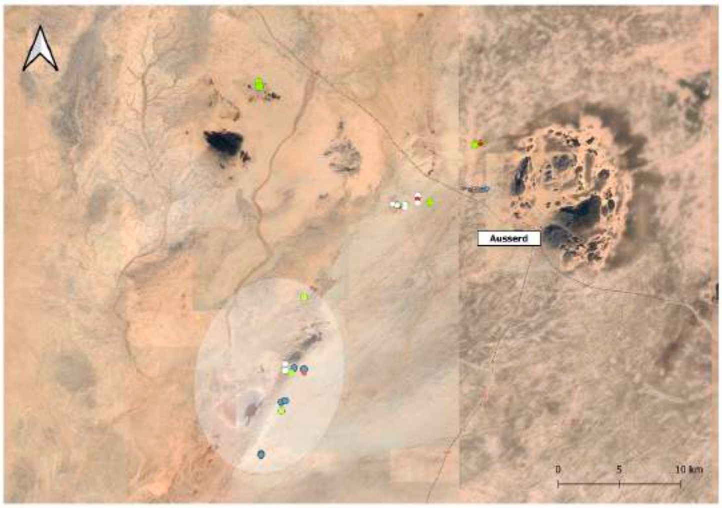

Figure 9. Group of measured monuments around Ausserd. Circles within the bigger white circle denote the tombs in the area of *Bouhlaryah* located in an *oued*.

In general, each area seems to host monuments of diverse morphology, and perhaps from different constructive periods, including Islamic tombs. This could reveal continuous occupation and the use of territory with special, ritual attributes by the same population that expresses internal cultural variations and by different cultural groups over time.

3.2. Orientation of the Monuments

Once the position and visibility of the surrounding territory were observed, other references involved in the construction of these structures were explored. In particular, azimuth and declination data were used to explore the connection between architecture and the possible observation of specific celestial targets.

The distributions of the azimuths and declinations for the full sample are shown in the curvigrams in Figures 10 and 11. In both curvigrams, a general pattern of orientations towards the eastern horizon is evident, primarily clustered slightly south of the southernmost rising position of the moon (the major south lunar standstill, MLS) at a declination of c. −2°. Major and minor lunastices are terms coined centuries ago to refer to the major and minor extreme declinations, respectively, reached by the moon in its movement along the horizon when it rises or sets [21].

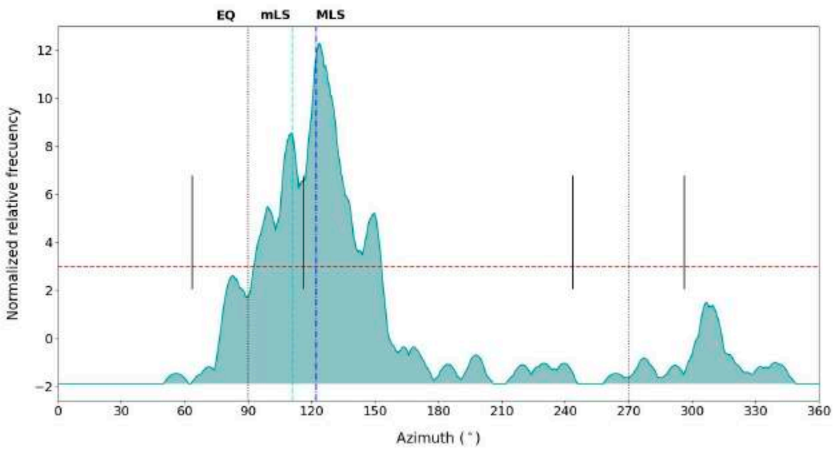

Figure 10. Curvigram of azimuth of the 217 dry-stone monuments in the sample. Vertical solid lines indicate the solar azimuths at the solstices, black vertical dotted lines the solar value at the equinoxes (EQ), and the blue vertical dashed lines the values for the rising moon at the minor south lunastice (mLS light blue) and major south lunastice (MLS, dark blue).

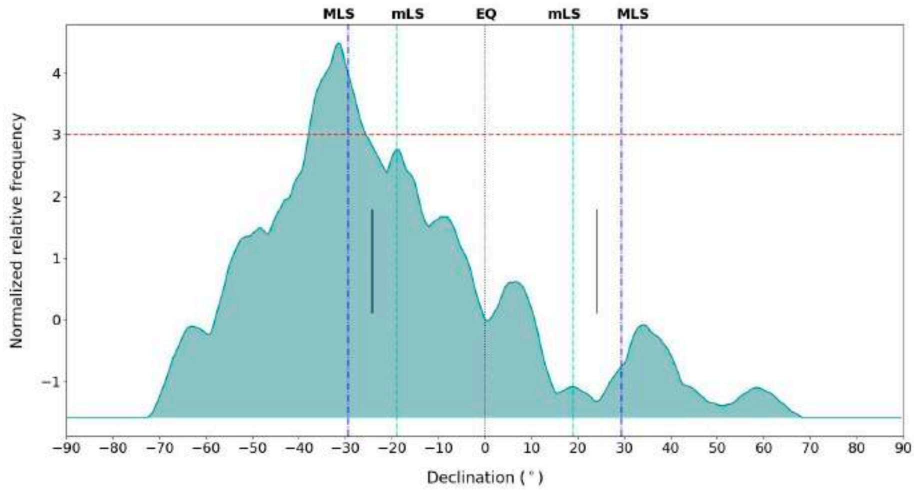

Figure 11. Curvigram of declination of the 217 dry-stone monuments in the sample. Vertical solid lines indicate the solar declinations at the solstices, black vertical dotted lines the solar value at the equinoxes (EQ), and the blue vertical dashed lines the values for the rising moon at the minor south lunastice (mLS light blue) and major south lunastice (MLS, dark blue).

In addition, there are also minor peaks for the rising moon in the south minor lunastice (mLS) and more dispersed values compatible with solar rising positions. Notably, 70% of the azimuths fall within 90° to 150°, an interesting result since it shows a general preference for the east, in particular to the south-east horizon, for a great part of the sample. This fact could point to a common practice preserved over time and that, due to the preservation of this trend over such great distances, the target or reference would have been above the land, in the sky.

Together with the main pattern towards the east, there are a number of minor peaks dispersed on the south and western sides of the horizon, in which other motivations such as particular topographical features or stars could have been prioritized, as will be discussed later.

This result agrees with the general trend of orientation towards the eastern, particularly southeastern, horizon previously found in similar monuments in other areas of the Sahara and southern Morocco [4,5,22–24], including the Free Zone of Western Sahara [6,7]; in those cases, however, the major pattern fit with solar and lunar rising positions, while in this sample, the main peaks of both declination and azimuth are out of the range in which such events can occur.

3.3. Orientation by Types

Although the east is the predominant direction for all types, with the exception of minor peaks in the western sector of the diagrams, particularities in the orientation patterns do arise when the data of each morphological group are displayed separately. Observing Figure 12, the circular tumuli and the monuments with structures (Figure 12, light and dark blue, respectively) present a main maximum coincident with the value south of the MLS identified in the curvigrams for the general sample previously mentioned (Figure 11); there is also a secondary concentration around the equinoxes for the tumuli and values dispersed in the west in both cases. The values for the crescents (Figure 12, in dark green) seem to be divided into three small groups, one around c. −15°, the second close to the south major lunastice (MLS), and the third out of the lunisolar arc, near a declination value of c. −45°. Lastly, the standing stone structures (Figure 12, in light green) present a less defined pattern with a wide maximum, roughly centered in the south minor lunar standstill rising value. This may be caused by the generally poor state of preservation of this type of construction.

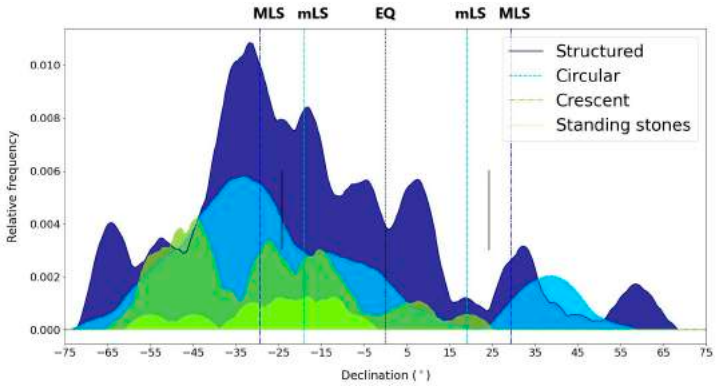

Figure 12. Curvigram of declination for the different types of monuments in the sample. Vertical solid lines indicate the solar declinations at the solstices, black vertical dotted line indicates the solar value at the equinoxes (EQ), and the blue vertical dashed lines indicate the values for the rising moon at the minor south lunastice (mLS light blue) and major south lunastice (MLS, dark blue).

3.4. Lunar Orientations: An Alternative

Although some of the values are distributed within the lunisolar sector of both azimuth and declination, a priori, one could be tempted to refute any kind of astronomical motivation behind the orientations of the general sample and the different sub-types of monuments.

A lunar explanation cannot, however, be completely discarded if we consider not just the rising but also different positions and phases of the moon above the horizon, such as the crescent or the waning moon. Since both have been used throughout history as timekeepers, for example, in the Muslim calendar [25], we have explored whether the same or similar references could be the case for the present context.

In particular, we compared the azimuths of the different monuments to models that reproduce the positions of the waning moon three days after and before the new moon around the winter solstice (Figure 13). The altitudes at which the moon is visible are more limited when the moon is "closer" to the sun, meaning that its visibility is progressively restricted to lower altitudes as the waning cycle advances. We, therefore used different models for various altitudes of the moon on those days, from 1° to 30° above the horizon.

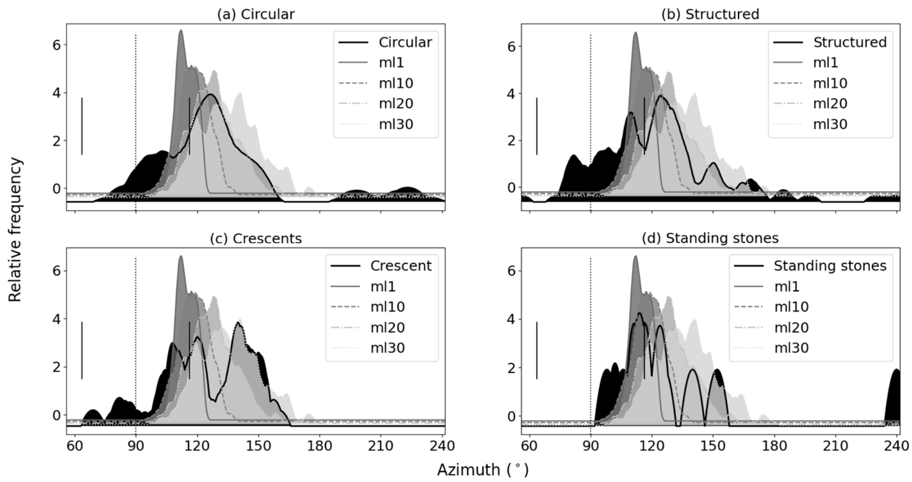

Figure 13. Comparison of the azimuth curvigrams for the different types of monuments in black (circular (**a**), with structure (**b**), crescents (**c**), and standing stone alignments (**d**)) with waning moon models around the winter solstice for different altitudes above the horizon: 1° (ml1), 10° (ml10), 20° (ml20), 30° (ml30) depicted from darker to brighter grey in this order. Vertical solid lines indicate the rising sun azimuths at the solstices and the black vertical dotted lines indicate the solar value at the equinoxes in all diagrams.

At first sight, the model that adapts better to the general distribution of azimuths is that of the waning moon roughly between 10° and 20° above the horizon (Figure 13, ml10 and ml20). A comparison was performed for each morphological group, and lunar altitudes of 20° appear more defined for the circular tumuli, monuments with structures, and the standing stones (Figure 13a,b,d), while crescent monuments adapt better to the lunar waning model at 30° (in green) (Figure 13c). However, the orientation patterns of these groups are more dispersed, covering a wider range of altitudes of the moon above the horizon.

4. Discussion

Firstly, no patterns of distribution in the territory were detected for any of the groups of monuments; however, they are present in diverse topographical areas, both high and flat and occasionally close to *oueds* (dry river basins), and sometimes different types of constructions share the same space. However, in cases such as that described for *Awsili Ngjir,* the topography could have partially conditioned the orientation, at least in those structures constructed on the slope of the mountain.

Regarding the orientations, the results of this study present a non-random distribution of orientations for the entire dataset, but they show a clear preference for the eastern sector of the horizon, particularly towards the south-east in both azimuth and declination. This follows the widespread trend present in the Prehistoric funerary monuments in North Africa and the Mediterranean [26,27]. In this case, fewer than half of the azimuths correspond to lunar or solar rising positions, and 70% of the values fall within a range of 90° to 155° with a major concentration at 121°, outside the lunisolar arc.

Nevertheless, an astronomical interpretation cannot be directly rejected if we consider the waning moon at different altitudes above the horizon, not exclusively at its rising, in the days around the winter solstice. During this phase, the moon is seen in the east and progressively rises shortly before sunrise; it emerges thinner and closer to the sun every day until the new moon when the sun lies behind this celestial body so that it is no longer observable until the next crescent phase.

While the moon is thinner, the altitudes at which it is observable decrease. For this reason, the data were compared against the positions of the waning moon at different altitudes, corresponding to a few days before the new moon. For the general sample, the model at 20° fits better to the main azimuth peak, although some variations were observed. It is, nonetheless, unlikely that any specific altitude above the horizon was sought out; however, it may address altitudes from 10°, and especially around 20° over the horizon, which could be better for the observation of this lunar phenomenon. This makes more sense if the atmospheric refraction in the usually dusty conditions of the desert is considered.

Lunar orientations are not always easily identifiable in the absence of additional archaeological or ethnographical material. This is usually because the moon shares part of its path on the horizon where it rises and sets with the sun and solar interpretations are normally simpler. Despite this, our results are not isolated. Similar orientation patterns related to crescent and waning moons were previously identified in Prehistoric burials in the Mediterranean and western Europe such as dolmens in Tunisia, southern France, and *Tombe dei Giganti* in Sardinia [28]. Such patterns were also linked to various lunar explanations for megaliths in the Iberian Peninsula, other regions of the Mediterranean, western Europe [29,30], and particularly in southern Morocco, the free zone of Western Sahara, and the horn of Africa [4–8,22–24,31]. In addition, the lunar crescent is frequently depicted in the Mediterranean basin and North Africa. Furthermore, ancient writers such as Herodotus mentioned in his books of history (IV, 37) how most Libyans made sacrifices to the sun and the moon. Likewise, centuries later, the Arab author Ibn Khaldun wrote that the early Berbers were worshippers of these same celestial bodies [32].

Moreover, the observation of the waning moon could make sense, in particular within a funerary context; in this case, it could be used as a metaphor for transit to the underworld, represented by the process of the waning of the moon that culminates with the darkness of nights without the moon. If so, this could suggest that, in the case that some type of lunisolar time-reckoning system was used, the new moon would be the marker of the end of a cycle or the beginning of a new one. The use of the lunar cycle for measuring time is widespread all over the world and it was in the past, as attested by the lunar orientations in several Pre- and Protohistoric monuments and by the lunisolar pre-Islamic calendars in North Africa and in the Canary Islands [33] (pp. 224–229) [34–37].

Furthermore, the fact that these lunar models represent the moon in the days around the winter solstice reinforces the strong symbolism behind the connection between rituality and death, with two clear moments of transition in both the lunar and the solar cycle. The winter solstice is the moment of the solar year coinciding with the longest night, and from this point, days start to be longer. For this reason, it has, traditionally, had deep symbolic connotations for several cultures around the world and throughout history. This event marks a transition from a darker to a brighter phase in the year, announcing the return of light and giving rise to a variety of festivities and rituals commonly (and still) performed around this date. By this association, the waning moon that disappears progressively during the winter solstice, perhaps depicting the return of the light, may have symbolized death and some kind of rebirth in the afterlife for the societies that built these monuments.

Finally, an alternative interpretation that should not be directly rejected may be found in the stars. Unfortunately, the absence of accurate dating of the monuments does not permit any exhaustive correlation between the orientations and the position of specific stars. This is caused by the movement of precession of the rotation axis of the Earth, which provokes a shift in the apparent position of the stars that mark the celestial poles. In consequence, the precession also affects the stars that can be observable from different positions on the globe at any epoch of history [18] (pp. 10–13). The period of precession is approximately 26,000 years, and the changes derived from it are appreciable from the present time to the various chronologies covered by the structures studied.

In the case of the present sample, the maximum at a declination of c. 32° fits the area of the sky covered by the star group formed by α and β-Centauri and the Southern Cross from 4500 to 3500 BCE, a chronology compatible with part of this sample. The same asterism was suggested as being the observed feature in several megalithic monuments in the Mediterranean, such as the Taulas in Menorca and in the Nuraghe in Sardinia [26,27]. This does not, in itself, prove any direct contact between this region of the Sahara with the Mediterranean, despite this hypothesis finding support from some authors [8] (pp. 201–203), [12]; however, it is possible that the same striking celestial body or asterism was well recognized among different cultures. The use of stars for both time reckoning and navigation in the desert is well attested for Sahrawis, mostly during the pre-colonial and colonial era before the war and exile. Sahrawis and many other Saharan tribes still divide the year according to the heliacal rising of specific stars, that is, the first visibility of a star above the eastern horizon just before sunrise. Stars and asterisms such as Canopus or Pleiades serve as guidance during night displacements and to determine the correct direction for praying [38,39]. Unfortunately, in the absence of a more accurate chronology for each type of monument, we can merely speculate about this hypothesis.

5. Conclusions

Most of the monuments in the sample follow the general pattern present in Prehistoric funerary architecture in North Africa and the Mediterranean, i.e., towards the eastern horizon, with a significant number of orientations towards the south-east, slightly south of the MLS limit.

One of the hypotheses explored was the role of the moon in the orientation of the monuments. The main orientation target could indeed be the waning moon around a key point of the solar cycle, i.e., the winter solstice; this may reinforce the use of some type of lunisolar calendar by the current communities of Western Sahara, the use of which is attested to in Pre-Islamic and Pre-Roman Sahara, North Africa in general, and the Canary Islands [33] (pp. 224–229). This would possibly result from the preservation of a time-reckoning system used for centuries, as well as from the existence of connecting networks between these and further Saharan communities and from farther regions from the Mediterranean and Atlantic Europe, a hypothesis proposed by several authors [8] (pp. 201–203), [11]. The fact that diverse types of monuments share the same areas could indicate the existence of sacred landscapes that were re-used for burial and religious practices through centuries, even millennia. On the other hand, such co-existence might also reflect pluralistic identity expressions within the same community.

Additionally, notions of the temporality of these peoples might be imprinted in the landscape by the location and orientation of the monuments, with the observation of the lunar phases and the solar cycle being potential markers of a time-reckoning system connected to funerary cults in which the moon disappearing and the sun being reborn would display ideas about the death and religion of these communities.

Furthermore, these monuments create a characteristic landscape that incorporates the ideas and practices of their builders related to the sky; indeed, they are located in a region that preserves impressive dark skies. These conditions make the areas studied, and the archaeological remains within them, exceptional candidates for consideration as astronomical tangible heritage, according to the UNESCO astronomical heritage convention [40] (pp. 5–6, 238, 260–272). In particular, the conditions meet the requirements for a declaration of a Starlight reserve and cultural landscape, in which the observation of starry nights and special astronomical phenomena are essential for the conservation of the integrity of this heritage, deeply connected to the firmament.

In the future, we would like to enlarge the sample to obtain more reliable results for each group of monuments and even include new types not present in the areas currently prospected. Unfortunately, fieldwork does not seem plausible in the short term due to the current geopolitical context. However, in the meantime, our aim is to continue research by analyzing a larger amount of data, which includes the present sample and data from other previously studied areas of North Africa, in order to broaden our understanding of the funerary practices, mobility, and possible interactions between different communities through time.

In conclusion, observing both the land and skyscape reveals how different aspects of the cosmovision of these peoples are incorporated in the creation of sacred and funerary landscapes, allowing the integration of this knowledge within the wider cultural context of the Prehistory funerary practices and beliefs. Most importantly, the results of this research could contribute to the preservation of this heritage, which is strongly threatened by a long-lasting political conflict, an active war, and its own dispersion across a vast territory under dispute, where an agreement seems to be a far-off prospect at the present time.

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Appendix A

Archaeoastronomical data of the measured monuments in the Western Sahara. The columns indicate, for each tomb, the latitude north (φ), longitude (λ), azimuth, height of the horizon in that orientation, the resultant declination values (δ), and the group it belongs to: Circular (CIR), with some structure (STR), crescents (CRES), and line of orthostats (ORT). Azimuth values were corrected from magnetic variation, but due to the poor preservation of the monuments, they are an approximation. The values of the height of the horizon were corrected from atmospheric refraction. Conservative errors of ±3° for the circular tumuli and ±1.5° for the other types were considered due to the high uncertainty in the measurements.

φ (°)	λ (°)	Azimuth (°)	Height (°)	δ (°)	Group
23.249	−15.317	97.0	1.8	−5.7	STR
23.133	−15.327	112.0	0.0	−20.2	STR
23.049	−15.275	168.0	0.0	−64.2	STR
23.053	−15.268	110.0	0.0	−18.3	STR
23.053	−15.268	106.0	0.0	−14.7	STR
23.053	−15.268	116.0	−0.3	−23.9	CIR
23.053	−15.268	140.0	−1.0	−45.4	STR
23.053	−15.268	126.0	−0.4	−32.9	CIR
23.053	−15.268	129.0	−0.4	−35.6	CIR
23.053	−15.265	106.0	0.0	−14.7	STR
23.055	−15.263	83.0	0.0	6.4	STR
23.052	−15.263	133.0	0.0	−38.9	STR
23.052	−15.264	126.0	−1.5	−33.4	STR
23.009	−15.266	111.0	0.2	−19.2	STR
23.009	−15.266	172.0	0.0	−65.7	STR
23.009	−15.266	128.0	0.0	−34.5	STR
23.009	−15.266	136.0	−0.4	−41.7	STR
23.009	−15.266	115.0	−0.4	−23.1	CRES
23.007	−15.265	106.0	0.0	−14.7	CRES
23.007	−15.265	89.0	0.0	0.9	STR
23.007	−15.265	166.0	0.0	−63.3	STR
23.007	−15.265	95.0	0.0	−4.6	STR
23.007	−15.265	135.0	0.0	−40.6	STR
23.007	−15.265	139.0	−0.4	−44.2	CRES
23.031	−15.278	172.0	0.0	−65.7	STR
23.032	−15.277	104.0	−0.4	−13.0	STR
23.032	−15.277	109.0	−1.4	−18.0	STR
23.045	−15.263	132.0	0.0	−38.0	CIR
23.045	−15.263	111.0	0.0	−19.3	STR
23.045	−15.263	134.0	0.0	−39.7	STR
23.045	−15.263	114.0	0.0	−22.0	STR
23.047	−15.262	290.0	0.0	18.3	STR
23.048	−15.262	264.0	−0.4	−5.7	STR
23.048	−15.263	278.0	−0.9	7.0	STR

φ (°)	λ (°)	Azimuth (°)	Height (°)	δ (°)	Group
23.049	−15.263	112.0	−0.9	−20.5	STR
23.049	−15.263	127.0	−0.5	−33.9	CIR
23.049	−15.263	122.0	−0.5	−29.4	CIR
23.045	−15.241	123.0	−0.4	−30.3	STR
23.045	−15.241	127.0	−0.4	−33.8	CIR
23.045	−15.241	110.0	−0.4	−18.5	CIR
23.041	−15.242	97.0	0.5	−6.2	STR
23.041	−15.241	108.0	1.0	−16.1	STR
23.039	−15.240	107.0	1.0	−15.2	STR
23.039	−15.239	197.0	−0.9	−62.4	STR
23.044	−15.237	111.0	0.0	−19.3	STR
23.045	−15.240	97.0	−0.5	−6.6	CIR
23.045	−15.240	126.0	0.2	−32.7	CIR
23.045	−15.240	111.0	−0.9	−19.6	STR
23.051	−15.236	121.0	0.0	−28.3	CRES
23.051	−15.236	129.0	0.0	−35.4	STR
23.051	−15.236	150.0	0.5	−52.5	CIR
23.051	−15.236	138.0	0.0	−43.1	STR
23.118	−15.225	120.0	−0.4	−27.6	STR
23.118	−15.225	102.0	0.5	−10.8	CIR
23.118	−15.225	130.0	0.4	−36.0	CIR
23.120	−15.221	183.0	0.0	−66.7	STR
23.130	−15.219	90.0	0.0	0.0	CRES
23.137	−15.218	99.0	0.0	−8.3	CRES
23.137	−15.218	98.0	0.0	−7.4	CIR
23.137	−15.218	112.0	0.0	−20.1	CIR
23.135	−15.216	96.0	−0.4	−5.7	CIR
22.671	−14.536	91.5	0.0	−1.4	STR
22.671	−14.536	221.5	0.7	−43.3	CIR
22.667	−14.536	196.5	0.0	−62.2	CIR
22.667	−14.535	128.5	3.0	−33.6	CIR
22.667	−14.535	138.5	1.5	−42.9	CIR
22.621	−14.364	155.0	0.0	−56.8	STR
22.621	−14.364	82.0	1.0	7.8	STR
22.621	−14.364	343.0	0.5	62.4	STR
22.621	−14.364	83.0	1.0	6.8	STR
22.621	−14.364	274.0	0.5	3.9	STR
22.621	−14.364	119.0	1.5	−25.9	STR
22.621	−14.364	121.0	2.0	−27.5	STR
22.621	−14.364	85.0	0.8	4.9	STR
22.621	−14.364	305.0	0.8	32.3	STR
22.621	−14.364	129.0	1.8	−34.6	STR
22.621	−14.364	310.0	0.0	36.4	STR
22.621	−14.364	311.0	0.0	37.3	CIR
22.621	−14.364	314.0	0.0	39.9	CIR
22.621	−14.364	133.0	2.8	−37.6	STR
22.621	−14.364	123.0	1.8	−29.4	STR
22.621	−14.364	128.0	2.4	−33.5	STR
22.621	−14.364	122.0	2.0	−28.4	STR
22.621	−14.364	302.0	0.5	29.5	STR
22.621	−14.364	134.0	3.0	−38.3	CIR
22.621	−14.364	126.0	2.0	−31.9	STR
22.621	−14.364	131.0	2.0	−36.3	STR
22.621	−14.364	139.0	1.8	−43.2	STR
22.621	−14.364	151.0	0.3	−53.6	STR
22.621	−14.364	99.0	1.8	−7.6	STR

φ (°)	λ (°)	Azimuth (°)	Height (°)	δ (°)	Group
22.621	−14.364	109.0	3.5	−16.1	CIR
22.621	−14.364	69.0	0.0	19.3	CRES
22.621	−14.364	149.0	0.0	−52.3	STR
22.621	−14.364	74.0	0.5	14.9	STR
22.621	−14.364	154.0	0.0	−56.1	STR
22.621	−14.364	319.0	0.5	44.4	STR
22.621	−14.364	99.0	1.3	−7.8	STR
22.621	−14.364	111.0	3.5	−17.9	CRES
22.622	−14.360	120.0	1.7	−26.7	CRES
22.622	−14.360	111.0	3.5	−17.9	CRES
22.622	−14.360	151.0	0.0	−53.8	CIR
22.622	−14.360	148.0	0.5	−51.2	CIR
22.622	−14.360	134.0	0.5	−39.6	CIR
22.622	−14.360	148.0	0.5	−51.2	CIR
22.622	−14.360	109.0	3.5	−16.1	CRES
22.573	−14.426	309.0	1.7	36.3	CIR
22.573	−14.426	309.0	1.7	36.3	CIR
22.573	−14.426	309.0	1.7	36.3	CIR
22.573	−14.426	122.0	9.8	−24.6	STR
22.573	−14.426	309.0	1.7	36.3	STR
22.573	−14.426	322.0	0.5	47.0	CIR
22.573	−14.426	306.0	2.0	33.8	CIR
22.573	−14.426	123.0	9.8	−25.5	STR
22.573	−14.426	131.0	8.8	−32.7	STR
22.573	−14.426	131.0	8.8	−32.7	CIR
22.573	−14.426	149.0	6.8	−47.8	STR
22.573	−14.426	111.0	8.0	−15.9	STR
22.573	−14.426	119.0	9.0	−22.5	CIR
22.573	−14.426	113.0	4.8	−19.1	CIR
22.573	−14.426	84.0	1.5	6.1	CRES
22.573	−14.426	124.0	4.8	−28.8	CIR
22.573	−14.426	119.0	7.5	−23.2	STR
22.573	−14.426	119.0	7.5	−23.2	CIR
22.573	−14.426	124.0	2.8	−29.8	CIR
22.573	−14.426	124.0	2.8	−29.8	CIR
22.573	−14.426	104.0	5.0	−10.9	CRES
22.573	−14.426	302.0	1.5	29.9	STR
22.573	−14.426	87.0	2.0	3.5	CIR
22.573	−14.426	102.0	3.8	−9.6	CIR
22.573	−14.426	104.0	3.8	−11.4	CRES
22.573	−14.426	104.0	3.8	−11.4	CIR
22.573	−14.426	80.0	1.3	9.7	STR
22.573	−14.426	111.0	1.8	−18.6	CRES
22.573	−14.426	103.0	1.8	−11.3	STR
22.621	−14.365	97.0	1.0	−6.1	CIR
22.621	−14.365	95.0	1.0	−4.2	STR
22.621	−14.365	96.0	1.0	−5.1	CIR
22.444	−14.508	126.0	0.0	−32.9	ORT
22.376	−14.534	114.0	−1.1	−22.5	ORT
22.375	−14.534	98.0	−1.1	−7.8	ORT
22.410	−14.518	152.0	−0.5	−55.0	ORT
22.410	−14.518	126.0	−0.5	−33.1	CIR
22.417	−14.518	106.0	−0.6	−15.0	ORT
22.418	−14.515	114.0	−0.6	−22.3	ORT

φ (°)	λ (°)	Azimuth (°)	Height (°)	δ (°)	Group
22.447	−14.515	126.0	0.0	−32.9	STR
22.447	−14.515	101.0	0.0	−10.2	STR
22.447	−14.515	91.0	0.5	−0.7	STR
22.447	−14.515	81.0	1.0	8.7	CIR
22.447	−14.515	125.0	0.5	−31.8	STR
22.447	−14.515	108.0	−0.6	−16.8	STR
22.447	−14.515	129.0	−1.1	−36.1	STR
22.447	−14.515	146.0	0.5	−49.7	CIR
22.447	−14.515	218.0	1.0	−46.2	CIR
22.447	−14.515	97.0	−0.6	−6.7	STR
22.447	−14.515	186.0	1.8	−65.1	STR
22.447	−14.515	280.0	0.0	9.2	STR
22.442	−14.514	136.0	0.0	−41.7	CIR
22.442	−14.514	124.0	0.0	−31.1	STR
22.442	−14.514	125.0	0.0	−32.0	STR
22.442	−14.515	81.0	0.0	8.3	STR
22.442	−14.515	80.0	0.0	9.2	CRES
22.442	−14.515	146.0	0.0	−50.0	CIR
22.442	−14.515	239.0	−0.6	−28.7	STR
22.442	−14.515	88.0	−0.6	1.6	CIR
22.442	−14.515	80.0	0.0	9.2	STR
22.442	−14.515	130.0	0.4	−36.3	STR
23.001	−14.500	120.0	1.1	−26.9	CIR
23.001	−14.500	130.0	2.0	−35.3	CIR
23.001	−14.000	90.0	0.5	0.2	STR
23.003	−14.000	127.0	0.5	−33.4	STR
23.003	−14.000	90.0	0.0	0.0	STR
23.003	−14.001	164.0	0.0	−26.5	STR
23.003	−14.001	240.0	2.0	−13.8	ORT
23.011	−14.001	122.0	0.0	−29.2	ORT
23.011	−14.001	140.0	0.0	−44.8	ORT
23.011	−14.002	130.0	1.0	−35.8	STR
23.011	−14.002	100.0	0.0	−9.2	STR
23.010	−14.002	340.0	0.0	59.9	STR
23.011	−14.002	115.0	0.0	−22.9	STR
23.011	−14.002	200.0	0.0	−59.88	CIR
22.500	−14.002	120.0	1.0	−27.1	CRES
22.500	−14.510	120.0	1.0	−27.1	CRES
22.500	−14.510	330.0	2.0	54.4	STR
22.500	−14.510	80.0	0.0	9.2	STR
22.500	−14.510	140.0	1.5	−44.2	CRES
22.500	−14.510	140.0	1.0	−44.5	CRES
22.500	−14.510	230.0	0.0	−36.4	CIR
22.500	−14.515	150.0	0.5	−52.8	CRES
22.500	−14.515	150.0	0.5	−52.8	CRES
22.501	−14.515	120.0	1.0	−27.1	STR
22.501	−14.511	120.0	1.0	−27.1	STR
22.501	−14.511	120.0	1.0	−27.1	CIR
23.155	−14.390	120.0	0.5	−27.1	CRES
23.155	−14.390	120.0	0.5	−27.1	STR
23.155	−14.400	160.0	0.75	−59.2	CRES
23.155	−14.400	143.0	0.5	−46.96	CRES
23.160	−14.400	145.0	1.0	−48.26	CRES
23.160	−14.388	230.0	1.0	−35.7	STR
23.160	−14.400	142.0	1.0	−45.9	CIR

φ (°)	λ (°)	Azimuth (°)	Height (°)	δ (°)	Group
23.160	−14.400	150.0	0.0	−52.8	STR
23.160	−14.400	56.0	0.0	30.9	STR
23.160	−14.400	155.0	1.0	−55.7	CRES
23.160	−14.410	135.0	1.0	−40.0	CRES
23.160	−14.392	150.0	0.0	−52.8	CRES
23.160	−14.392	141.0	0.5	−45.3	CRES
23.160	−14.392	135.0	0.5	−40.3	CRES
22.581	−14.410	109.0	1.0	−17.1	STR
22.578	−14.410	135.0	1.0	−40.2	STR
22.575	−14.410	294.0	2.0	22.9	STR
22.575	−14.400	160.0	0.0	−60.2	STR
22.574	−14.421	142.0	3.5	−44.7	CRES
22.574	−14.421	335.0	1.0	57.5	STR
22.574	−14.421	147.5	1.5	−50.2	STR
22.573	−14.421	146.0	0.5	−49.7	STR
22.571	−14.421	315.0	2.0	41.8	CIR
22.574	−14.43	303.0	0.5	30.4	STR
22.443	−14.50	125.0	0.5	−31.8	CRES
22.443	14.505	130.0	0.5	−36.2	CRES
22.440	14.505	150.0	0.5	−52.9	CRES
22.440	14.510	135.0	0.0	−40.8	STR

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